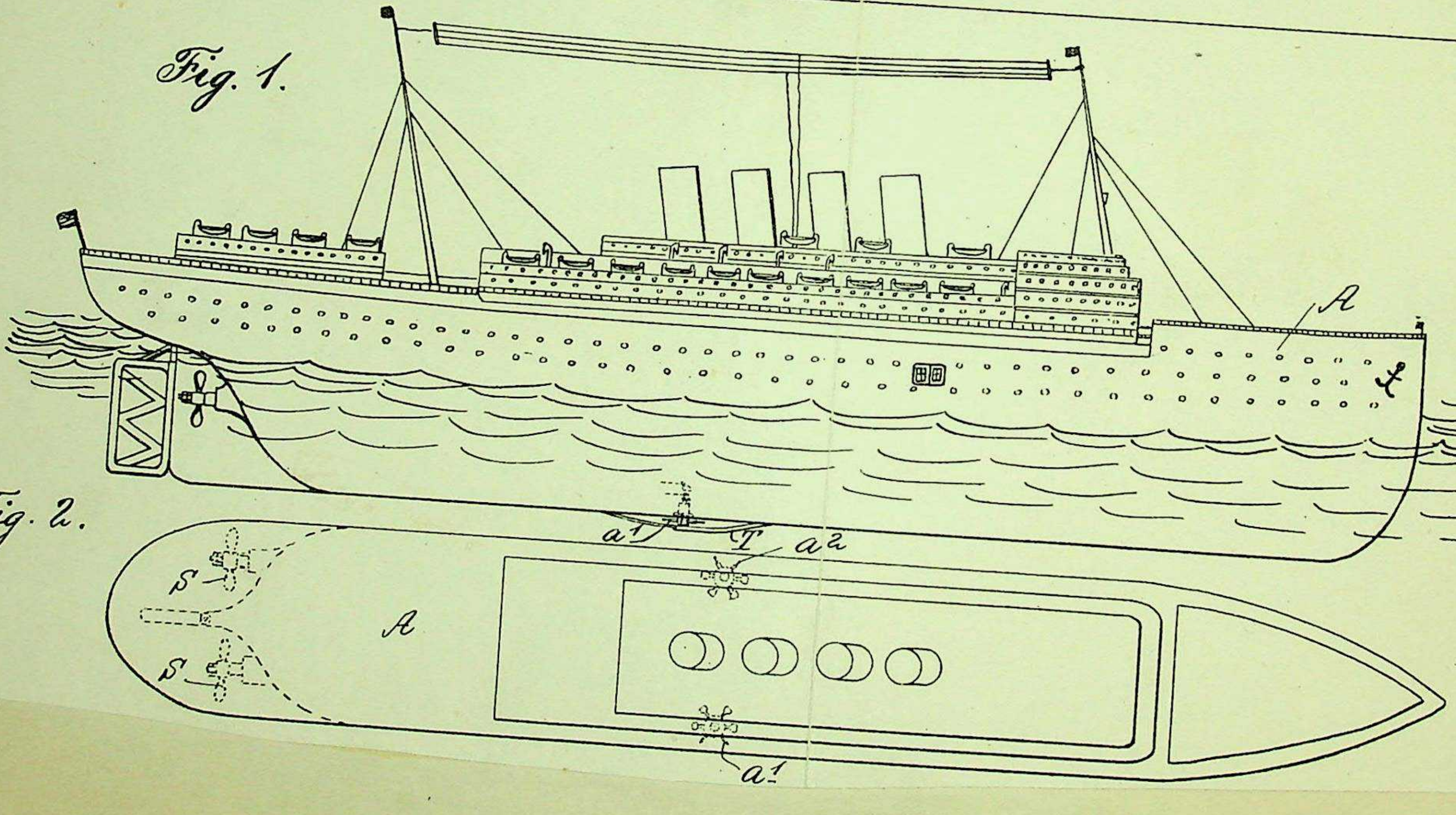
148,596. ICRE'S COMPLETE SPECIFICATION.

Fig. 1.

Fig. 2.



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SHEET 2.

Fig: 1ª

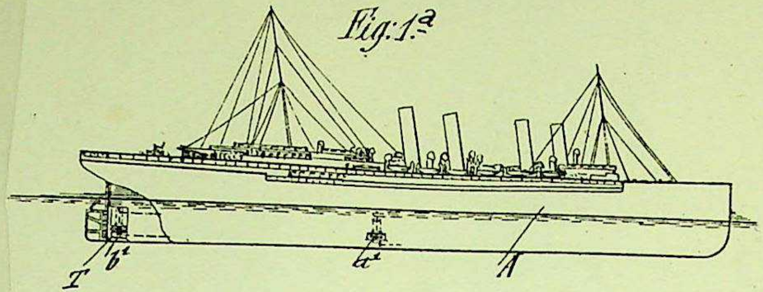

Fig: 2ª

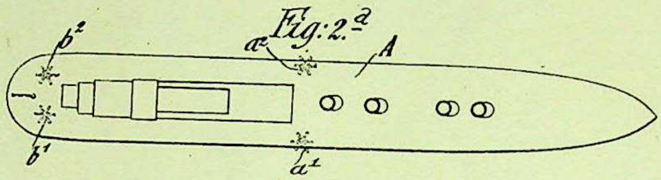

Fig: 3.

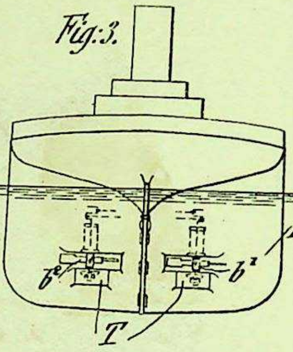

Fig: 4.

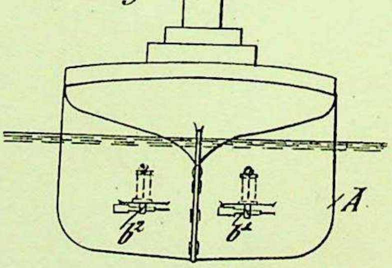

Fig: 5.

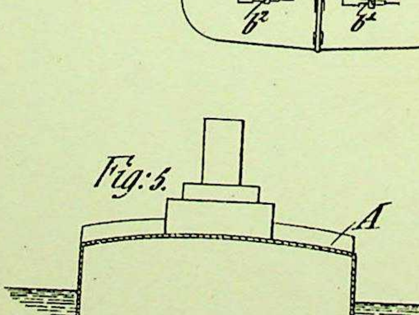

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Fig. 7.

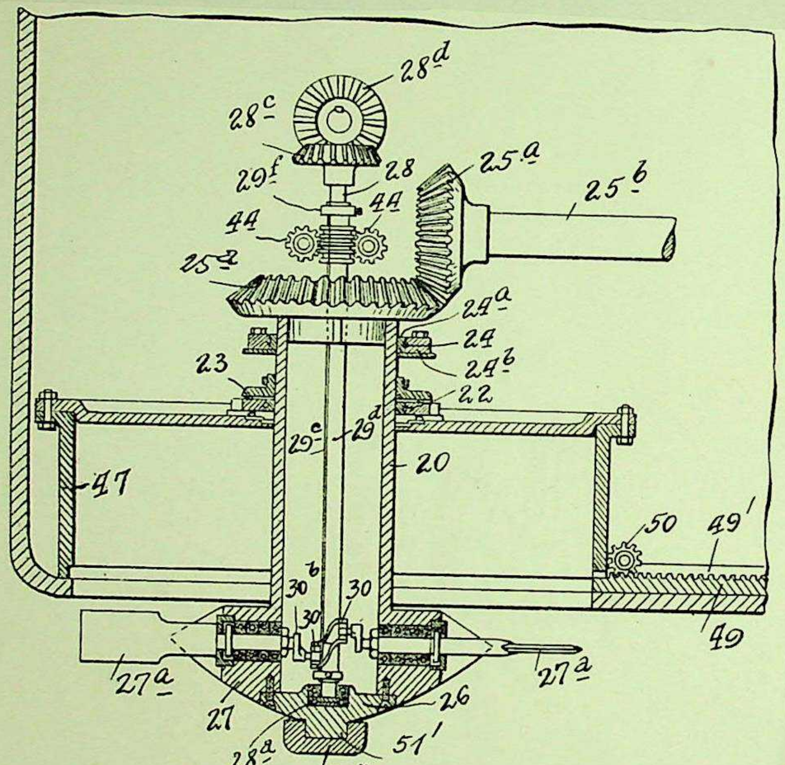

Fig. 6.

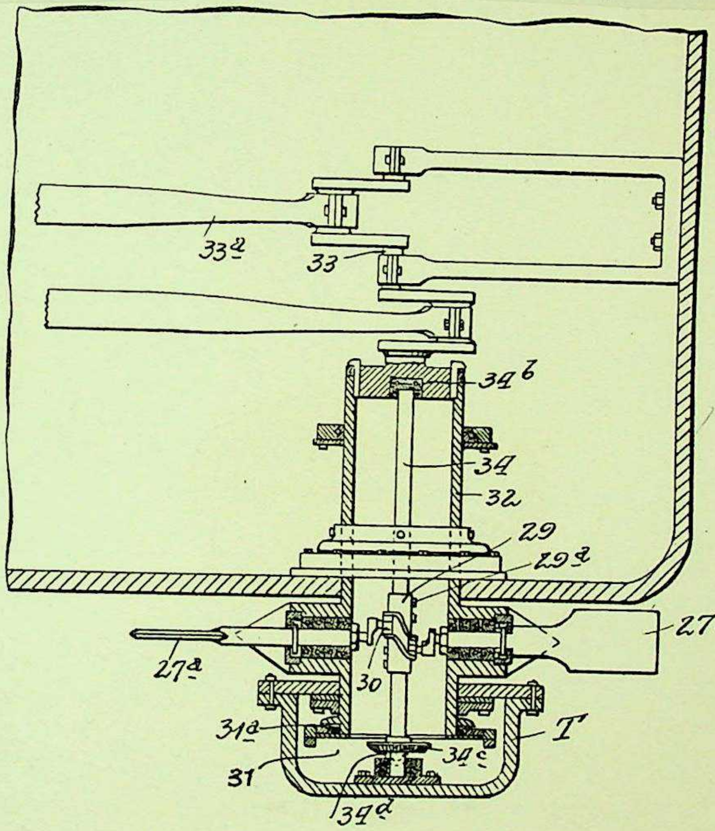

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Fig. 7a

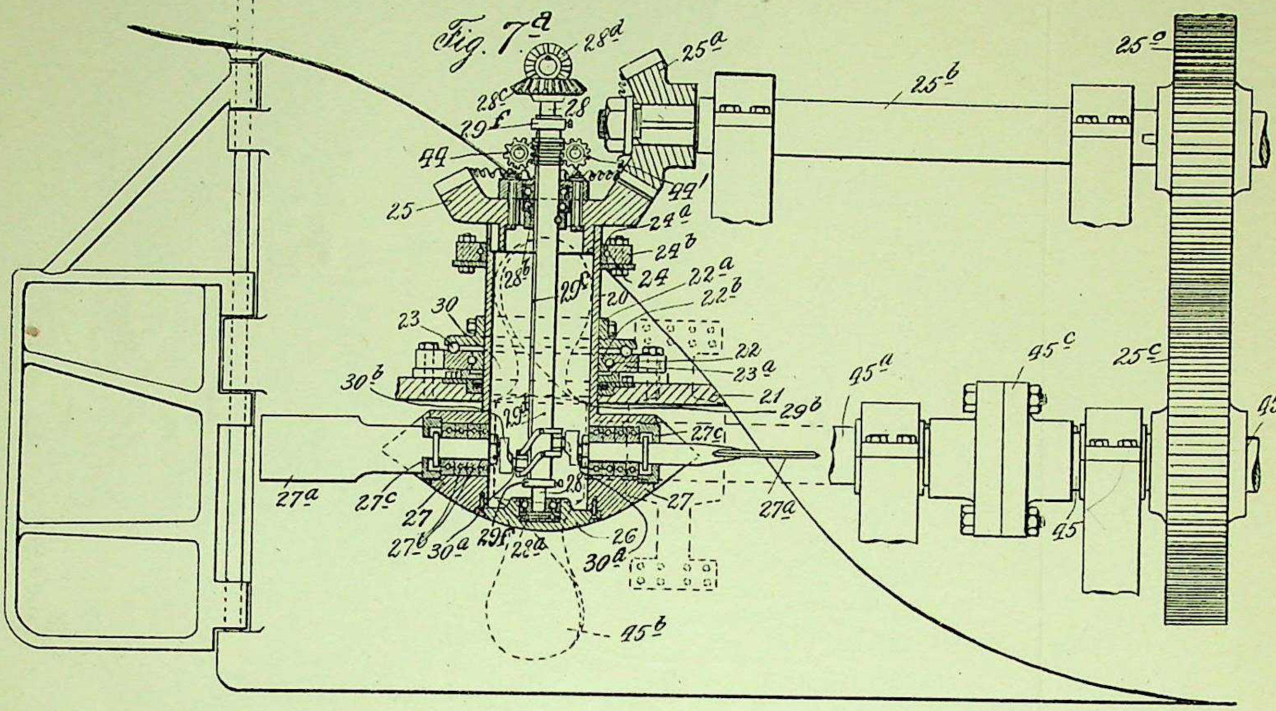
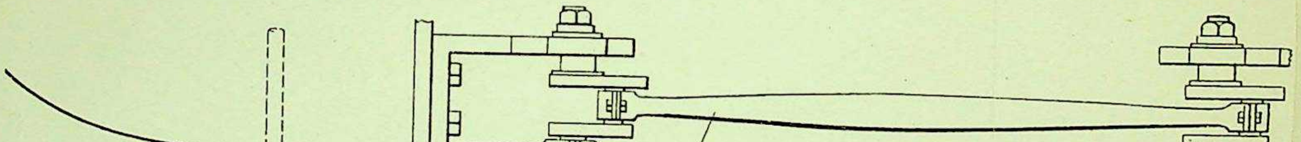


Fig: 6a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SHEET 3.

Fig. 10.

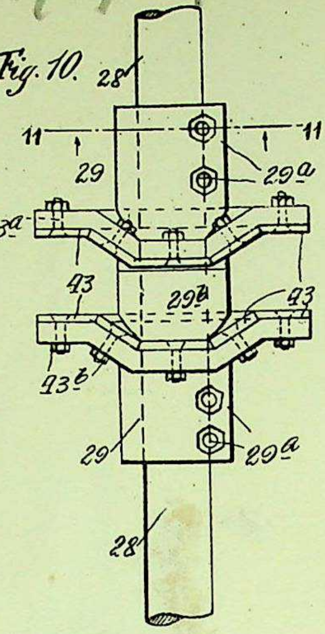
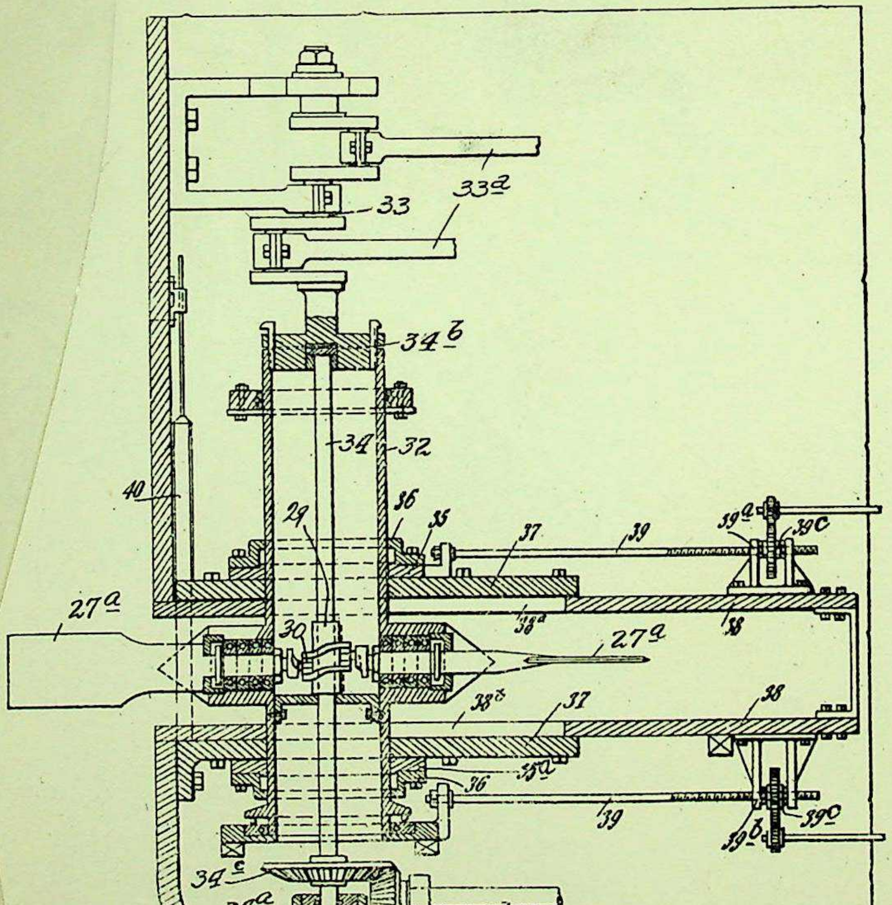


Fig: 8.



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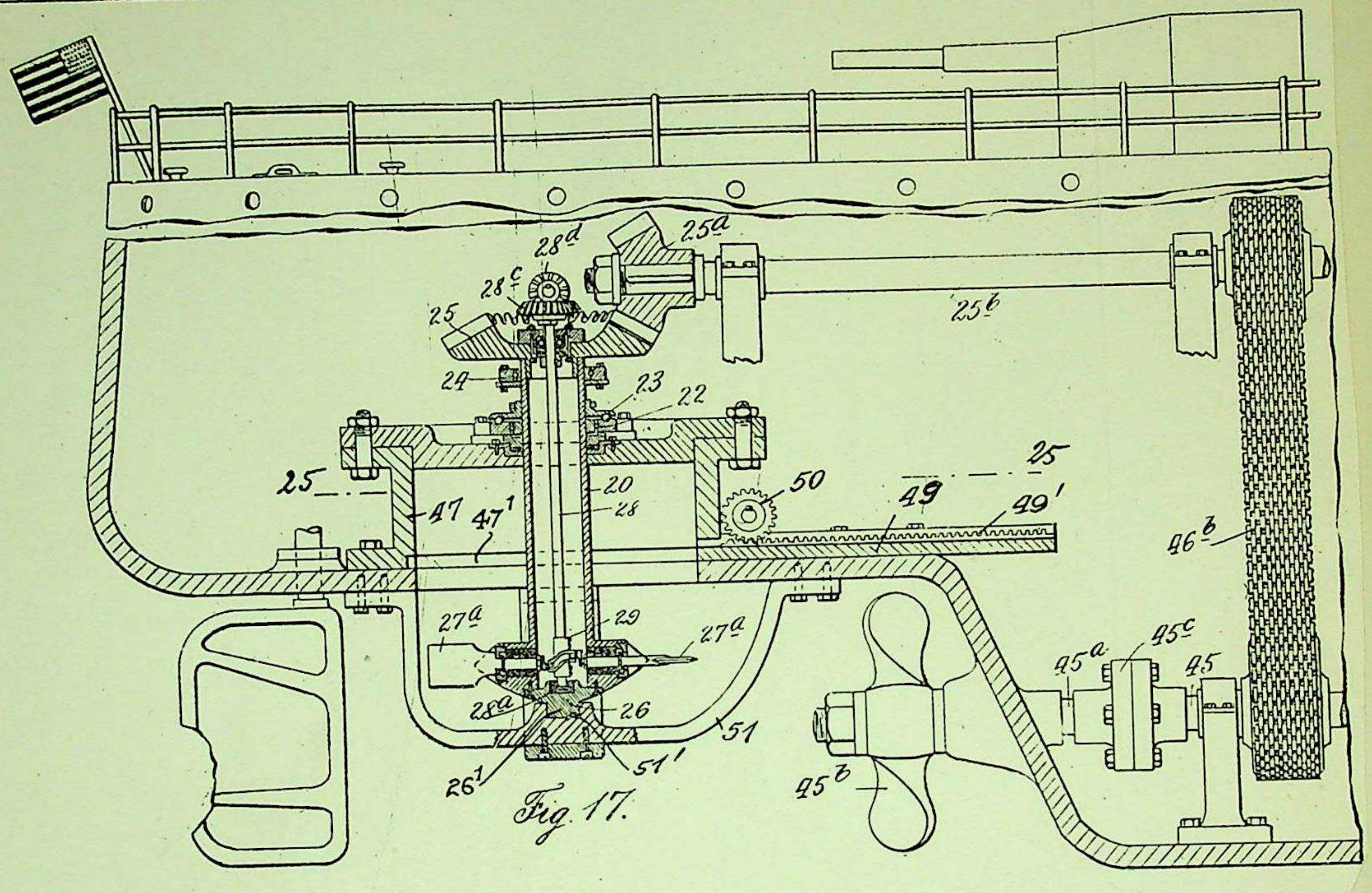


Fig. 17.

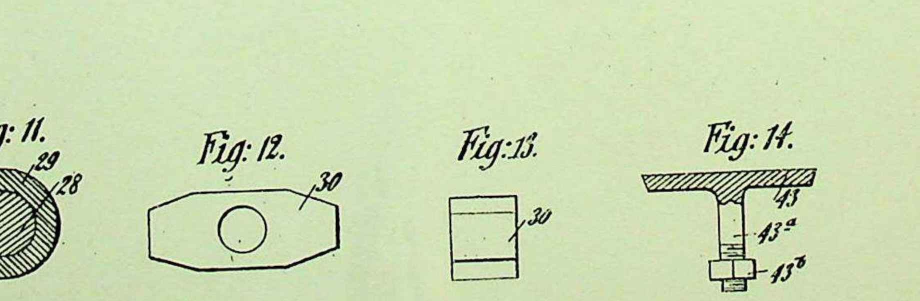


Fig. 9.

Fig: 11.

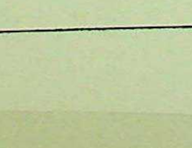


Fig: 12.

Fig: 13.

Fig: 14.

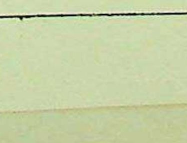


Fig: 15.

Fig. 16.

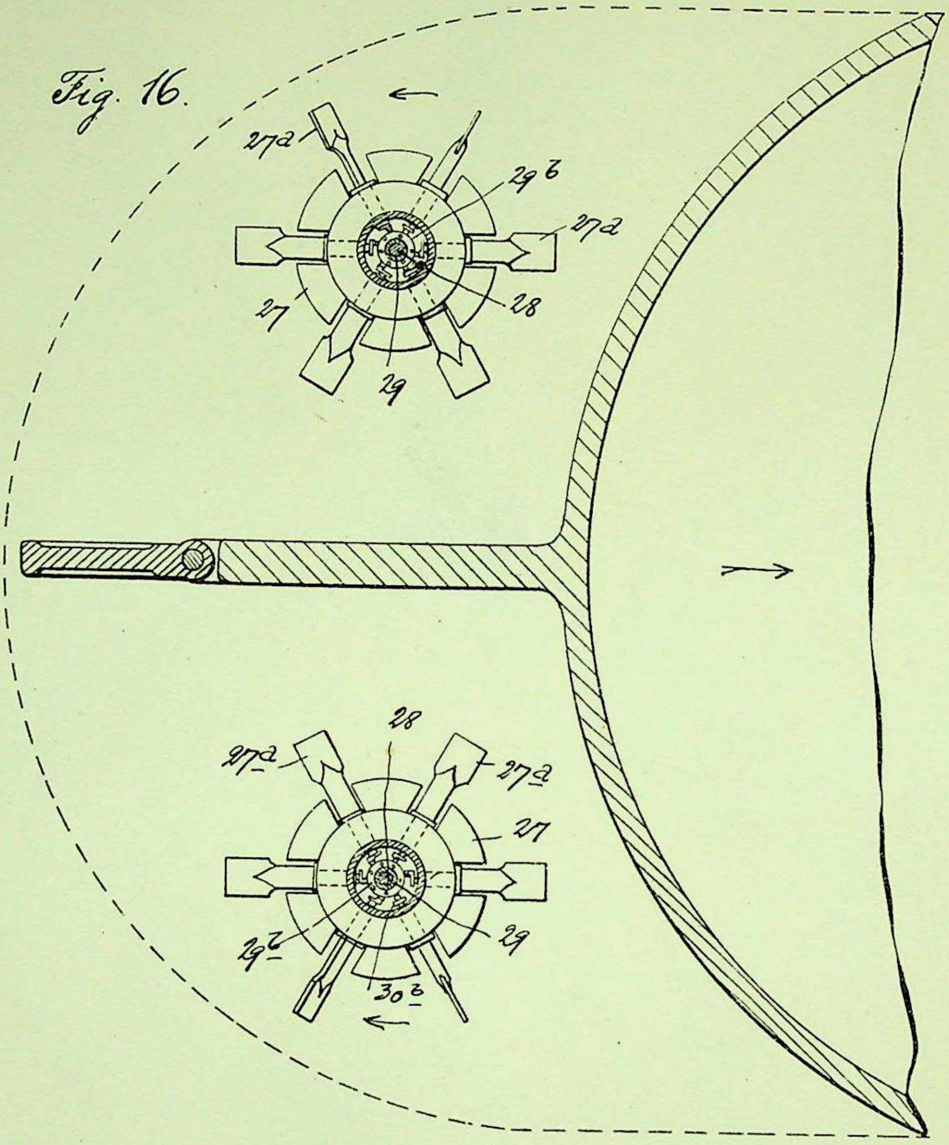
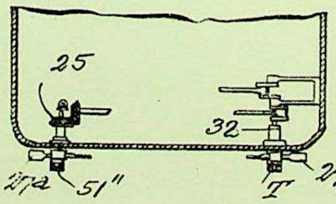


Fig. 26.



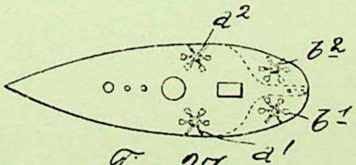


Fig. 27.

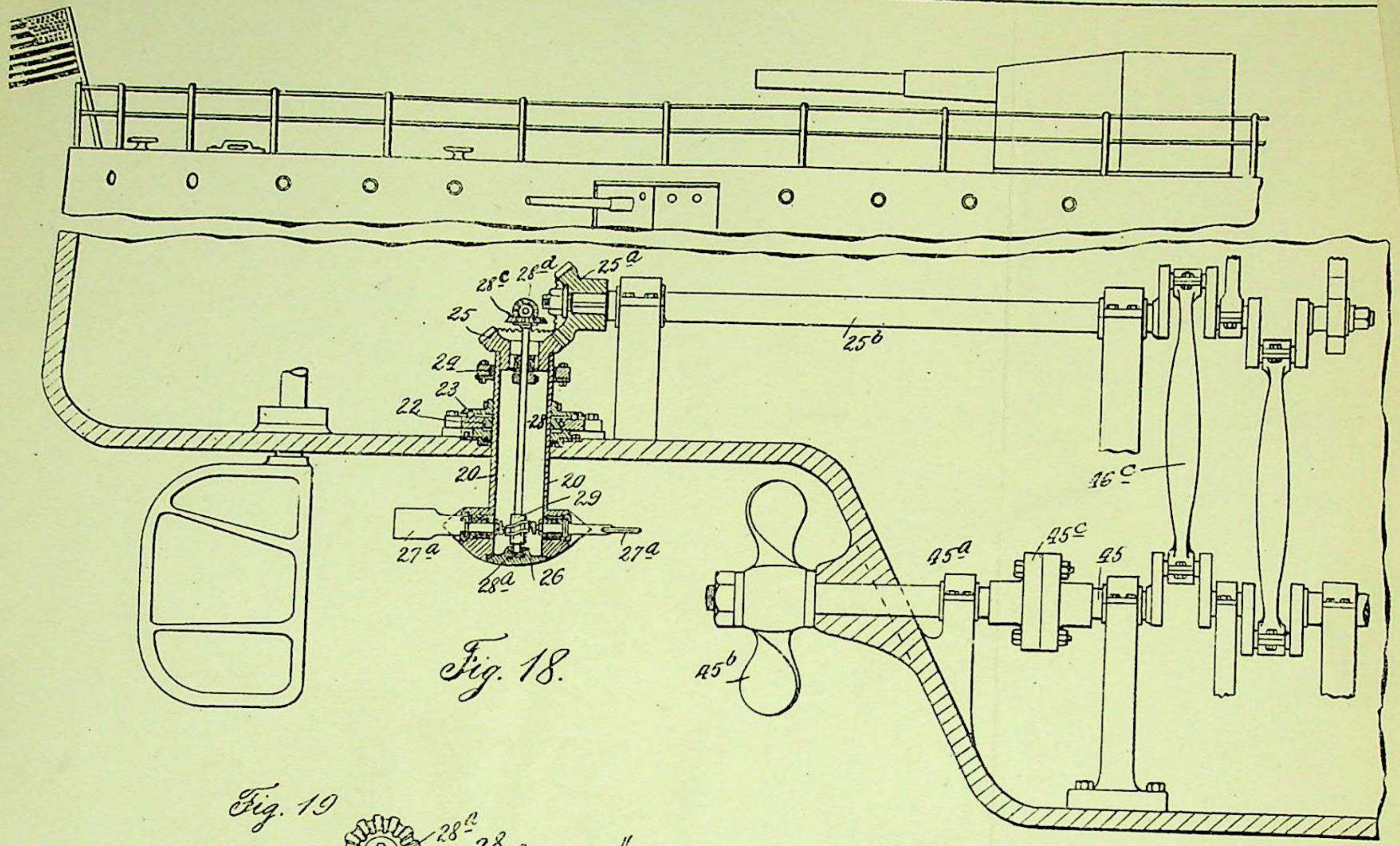
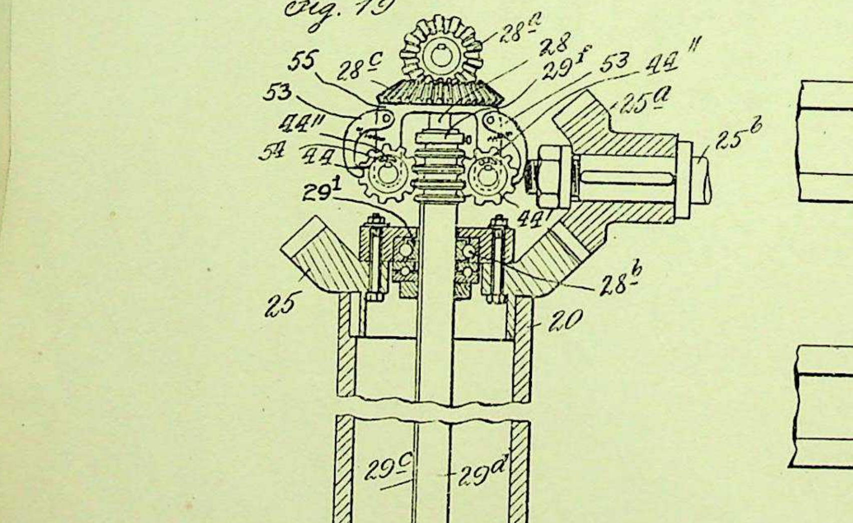


Fig. 18.

Fig. 19



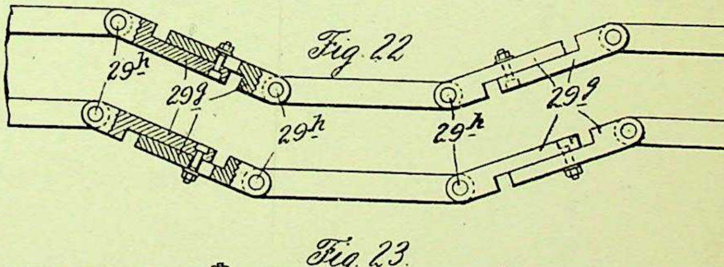
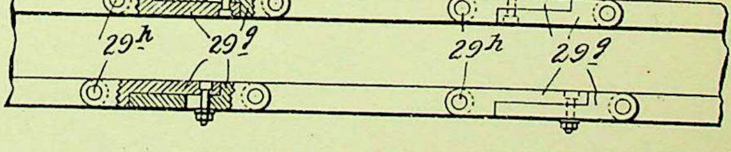


Fig. 22

Fig. 23.



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SHEET 6.

Fig. 1b.

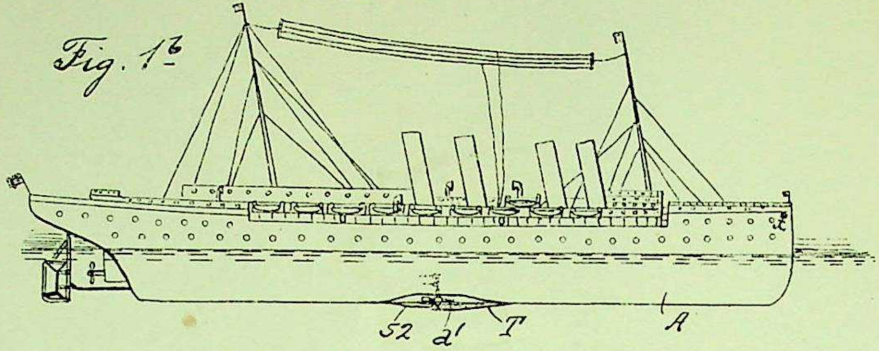


Fig. 2b.

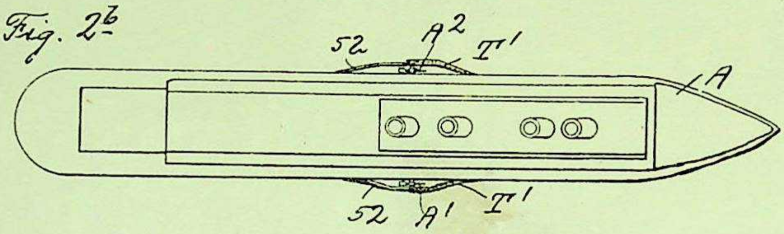


Fig. 28.

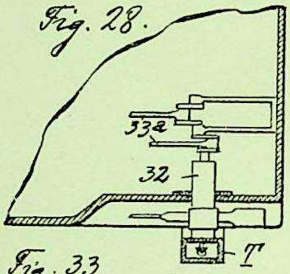


Fig. 29

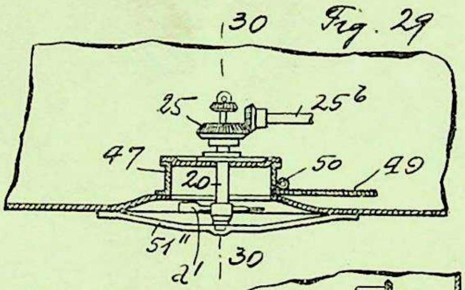
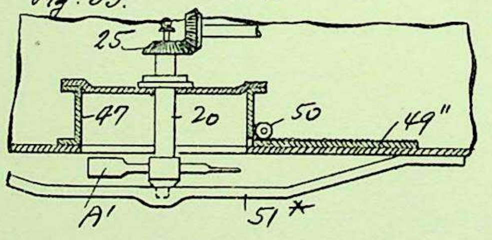


Fig. 33.



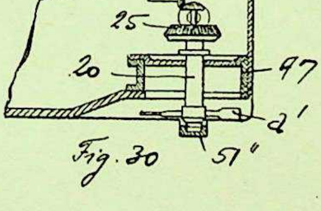


Fig. 30

Fig. 31

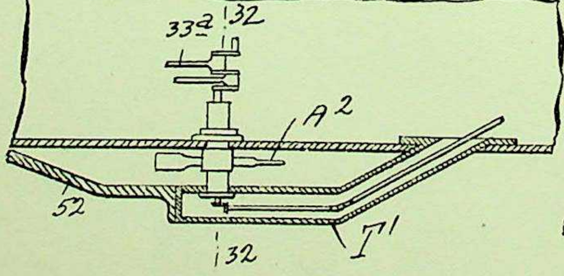


Fig. 32.

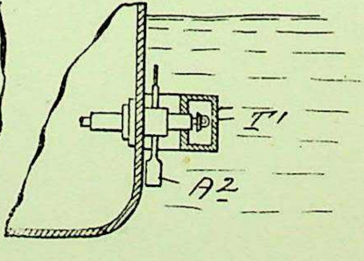


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Fig. 20

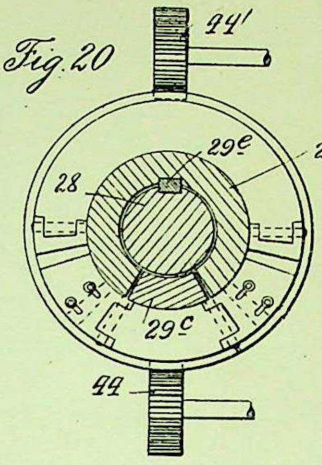


Fig. 21

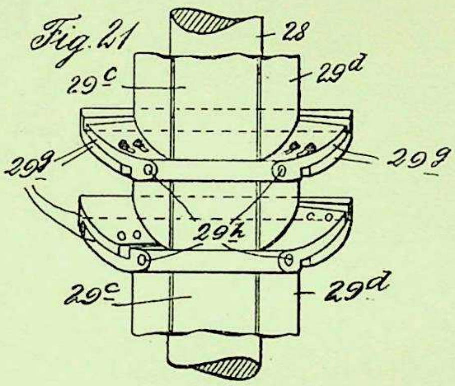


Fig. 25.

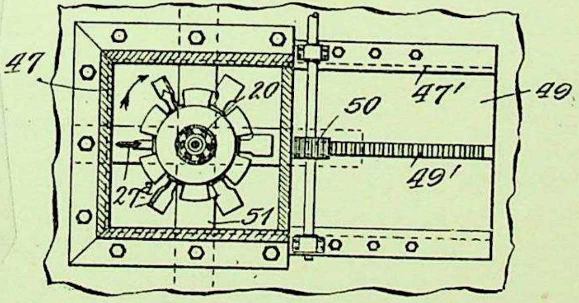
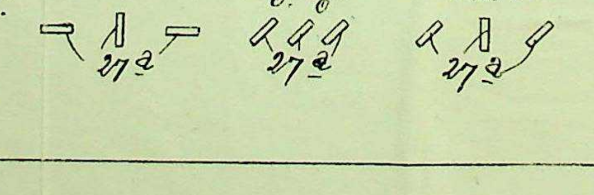


Fig. 24.



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PATENT SPECIFICATION

Application Date: Mar. 20, 1919. No. 7001/19.

Complete Accepted: July 20, 1920.

148,596

COMPLETE SPECIFICATION.

Improvements in, and relating to, Structures Adapted for use as Propellers for Ships and other Crafts, and also for Pumping and other purposes.

I, Jean Baptiste Icre, of 53, Christopher Street, in the Borough of Manhattan, City, County, and State of New York, United States of America, Inventor, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to propellers for vessels and crafts of various characters, whether intended to navigate on or below the surface, of the water or in the air.

The invention has particular relation to feathering-blade propellers of the type, in which the blades, as they revolve about the axis of the propeller, are turned at the proper time about their individual axes, by the action of a normally stationary cam or track.

The objects of the present invention are to secure better and more varied results in the operation of the propeller, by a novel construction and arrangement of the cam or track, also, in certain cases, to combine a feathering-blade propeller of the present construction, with a screw propeller, in a manner which insures efficient operation of both.

According to one feature of the present invention the normally stationary cam or track for guiding and operating the members effecting the swinging of the feathering blades on their axes comprises two portions connected by intermediate portions to form a continuous contact surface or surfaces, said two portions being located in planes at equal distances from and on opposite sides of the plane containing the blade axes and perpendicular to the axis of rotation of a tubular rotary member surrounding the cam or track and on which the blades are mounted.

According to a further feature of the invention the normally stationary cam or track for guiding and operating the member effecting the swinging of the feathering blades on their axes comprises two portions located in planes perpendicular to the axis of rotation of a rotary member carrying the blades, and means is provided whereby said portions can be adjusted longitudinally relatively one to the other or axially with respect to the axis of rotation of the rotary member.

It may here be pointed out that a feathering blade propeller of the above type has already been proposed in which the normally stationary cam or track consisted of a continuous surface or surfaces and it is also known according to another arrangement, to mount the blades on a tubular rotary member surrounding the cam or track and these features are not therefore claimed *per se*. It is also known to alter the direction in which the blades exert their force by turning the cam or track axially with respect to the axis of rotation of the rotary member carrying the blades.

The invention also consists in certain novel subsidiary features, more fully described hereinafter and pointed out in the appended claims, for enabling the propeller to be inspected and repaired more readily, and for securing other

[*Price* 1/-]

advantages that will be set forth in the course of this description.

Reference is to be had to the accompanying drawings, in which Figs. 1, 1^a, and 1^b are side elevation of ships, (for water navigation) having my improved propellers applied thereto; Figs. 2 and 2^a are plan views corresponding to Figs. 1 and 1^a respectively while Fig. 2^b is a plan view showing my improved propellers arranged to rotate about a horizontal axis, and not about vertical axes, as in other figs. so far enumerated; Fig. 3 is a rear elevation of the ship shown in Figs. 1^a and 2^a. Fig. 4 is a rear elevation showing a slightly different arrangement, such as may be employed in conjunction with vessels of various types; Fig. 5 is a cross section of the vessel shown in Figs. 1^a and 2^a; Fig. 6 is a partial cross section of the construction shown in Figs. 1 and 2; Fig. 6^a is a partial longitudinal section near the stern of the ship shown in Figs. 1^a, 2^a, and 3; Fig. 7 is a partial cross section illustrating a construction slightly different from the one shown in Fig. 6; Fig. 7^a is a view similar to Fig. 6^a but representing another construction; Fig. 8 is a partial cross section showing still another arrangement of my improved propeller; Fig. 9 is a diagrammatic developed view illustrating the manner of swinging or "feathering" the blades, say from a horizontal to a vertical position and *vice-versa*; Fig. 10 is a detail side-view of the cam-track construction employed in Fig. 8; Fig. 11 is a cross section on line 11—11 of Fig. 10; Fig. 12 is a top view of one of the slide-blocks applied to the ends of the cranks of the blade-shafts, and Fig. 13 is a corresponding end-view; Figs. 14 and 15 are side-views, partly in section, of face-plates used in conjunction with this mechanism; Fig. 16 is a partial sectional plan showing two stern propellers; Figs. 17 and 18 are longitudinal sections showing a slightly different power-transmitting mechanism and a somewhat different propeller arrangement, these views representing a vessel of the type of the Argentine battleship "Rivadavia"; Fig. 19 shows upon an enlarged scale, certain parts at the central portion of Figs. 7^a and (substantially) 7; Fig. 20 is a horizontal section on the line 20—20 of Fig. 19; Fig. 21 is a partial side elevation taken in the direction of the arrow 21 in Fig. 19; Figs. 22 and 23 are partial developed views of the cam-track employed in Fig. 7^a (and several others), illustrating two different positions of said track; Fig. 24 is a series of diagrams illustrating different positions which may be taken by the adjustable track of Figs. 7^a and 19 to 23 inclusive, and also indicating the blade movements resulting from such positions; Fig. 25 is a horizontal section on the line 25—25 of Fig. 17; Fig. 26 is a cross-section combining Figs. 6 and 7; Fig. 27 is a plan view indicating how four of my improved propellers may be arranged on a submarine; Fig. 28 is a partial vertical cross section of the construction shown in Fig. 1^b; Fig. 29 is a longitudinal vertical section of a slightly different arrangement; Fig. 30 is a vertical cross section on the line 30—30 of Fig. 29; Fig. 31 is a partial horizontal section of the construction shown in Fig. 2^b; Fig. 32 is a partial vertical section on line 32—32 of Fig. 31; and Fig. 33 is a partial horizontal section, somewhat similar to Fig. 31, but showing certain modifications.

In Figs. 1 and 2 I have indicated an ocean liner A provided amidships, at each side, with propellers a^1 and a^2 of my improved type, besides having the usual screw propellers S; the propellers a^1, a^2 are preferably under the bottom of the ship, being mounted as will be explained in detail hereinafter. Figs. 1^a, 2^a, 3 and 5 show two propellers a^1, a^2 of the improved type arranged amidships, but considerably above the bottom of the hull, together with stern propellers b^1, b^2 (likewise of the improved type) in a relative position corresponding to that of twin-screw propellers. In Figs. 3, 6, 6^a, 8, and 26, the ship's hull is provided with tunnels beneath the improved propellers, or some of them, to contain part of the machinery, while in Figs. 4, 7^a, 17, 18, 19, 29, 30 and 31 the lower faces of the propellers are fully exposed. In Figs. 1^b and 28 the propeller is located in a pocket, and substantially flush with the ship's bottom, and a tunnel, such as T, is provided for receiving part of the machinery. A similar tunnel T^1 is shown in Figs. 2^b and 31; in these figs. as well as in Fig. 32, the improved propeller rotates about a horizontal axis, whereas in the other views the propeller axis is vertical. I desire it to be understood that the propeller axis may be arranged in different positions, and that the propeller blades may either project beyond the sides of the ship, as in Figs. 2^a and 5 (at a^1, a^2), or never sweep beyond the sides, as in Figs. 2, 6, 7, and 26, and the blades, when rotating about vertical axes, may be either above or below the bottom of the ship, or practically flush with it. All these different arrangements are considered as falling within the scope of my invention. Fig. 27 shows in plan, the preferred arrangement of propellers for a submarine, such arrangement being similar to the one in Fig. 2^a, but in this case the propellers would preferably be located below the bottom of the hull. Various other details of arrangement will be explained below.

Referring to the detail construction shown particularly in Figs. 7^a and 19, the device comprises a hollow main-shaft 20 extending through the hull 21 of the vessel, and supported by means of an anti-friction neck-and-step bearing, composed of a ring 22^b on the shaft, in engagement with bearing balls 22 running on an outer ring 23^a secured to the hull, while another ring 22^a secured to the shaft 20 engages bearing balls 23 which run on the upper face of the stationary ring 23^a. The upper end of the main-shaft is supported in an anti-friction bearing which comprises a ring 24^a carried by the shaft, an outer ring 24^b supported by the hull, and bearing balls 24 interposed between said rings. To the upper extremity of said shaft is secured rigidly a bevel gear 25, in mesh with a bevel pinion 25^a on a shaft 25^b operated from the driving shaft 45 of the engine by gearing 25^c. To the lower end of the shaft 20 is secured a cap or closure 26 which serves to prevent the access of water to the operating parts, and also to support and retain a body of lubricant, so that the operating parts may run in oil or the like. At the lower end of the shaft 20 are provided radial enlargements or hubs 27, in which are supported the shanks of the feathering blades 27^a, by means of ball-bearings 27^b; suitable packings, held in position by nuts or caps 27^c, are provided in said hubs to prevent the entrance of water into the hollow main-shaft. Within the shaft 20 is arranged centrally or axially, a normally stationary shaft 28, supported at its lower end in an anti-friction neck-and-step bearing 28^a provided on the inner side of the closure 26. Bevelgears 28^c and 28^d, applied at the upper end of said center-shaft 28, serve to turn the latter, when desired, for a purpose to be stated presently. The closure 26 is also shown as forming with the shaft 20, an annular groove or catch-recess to receive metal-chips or grit from the machinery, and prevent them from reaching the bearing 28^a.

On the lower portion of the center-shaft 28 are mounted certain parts forming a normally stationary cam-track held to turn with the shaft 28 at such times as said normally-stationary shaft 28 is turned for adjusting or varying the operation of the blades as set forth hereinafter. This cam-track might be secured to the shaft 28 rigidly, as shown at 29 in Figs. 6, 6^a, 8, 10, 11, 17, and 18, such track being composed of a relatively short horizontal lower portion (*m* in diagram I, Fig. 24), a relatively long horizontal upper portion (*n*), and two inclined connecting or intermediate portions (*o*). In detail, the rigidly-connected cam may be constructed as shown in Figs. 10, 11, 14, and 15, where such track consists of two separate sleeve-sections 29, which are attached to the shaft 28 by means of cross-keys 29^a (Figs. 10 and 11), or rings or other suitable clamping means may be employed. Said sleeve-sections are provided around their abutting ends or edges with flanges forming a cam-track having the horizontal and inclined portions referred to above. As shown in Figs. 10, 14, and 15, the sleeve-sections are provided at their flanges with face-plates 43, which are attached to said flanges by shanks 43^a extending at right angles to said flanges and secured by nuts 43^b. The shank 43^a may be a separate piece, as in Fig. 15, or integral with the face-plate 43, as in Fig. 14. These face-plates can be removed and renewed readily when worn, so that the sleeve-sections will be kept in proper condition for governing or producing the desired feathering action of the blades 27^a.

The cam-track shown in Figs. 7, 7^a, and 19 to 23, is of a somewhat different construction, as will be described below, but in the position shown in Figs. 7, 7^a, and 19 to 22 inclusive, it has the same characteristics of shape (diagram I, Fig. 24) and the same function as the track secured rigidly to the shaft 28 as in Figs. 6, 6^a, 8, 10, 11, 17, and 18, that is to say, it has a relatively long horizontal upper portion, a relatively short horizontal lower portion, and two oppositely-inclined connecting or intermediate portions. Between the flanges which form the cam-track are guided slide-blocks or shoes 30 which are applied pivotally to the wrist-pins 30^a of cranks 30^b, keyed or otherwise secured to the reduced inner ends of the shanks of the blades 27^a. As the hollow main-shaft 20 is rotated (the center-shaft 28 and the cam-track connected therewith remaining stationary), the slide-blocks 30 will travel between and along the cam-flanges of said track-sections. As long as the slide-blocks 30 are at the relatively long upper portions *n* (Fig. 9) of the cam-track, the blades 27^a will be horizontal, as shown at the right in Figs. 6^a, 7, and 7^a, and when the slide-blocks travel along the inclined cam-portions *o* (Fig. 9), the blades will be turned gradually on the horizontal (or in some cases, vertical) axes of their shanks, and when the slide-blocks reach the relatively short lower portion *m* (Fig. 9) of the cam-track, the blades 27^a will assume a vertical position, as shown at the left in said Figs. 6^a, 7, and 7^a. Speaking in a more general way, since the shaft 28 need not be vertical in all cases, the blades will take an edgewise position while the slide blocks 30 are travelling along the track portions *n*, and a flatwise or active position while the slide-blocks 30 are travelling along the track portions *m*. The well-known feathering action is thus obtained, by which (assuming a vertical arrangement of the shafts 20, 28) the vessel is propelled forward if the shaft 20 is rotated in the proper direction for this purpose. The dotted lines in Fig. 7^a show the arrangement of a screw-propeller 45^b of ordinary construction, and thus indicate one way of substituting my new propeller for such ordinary screw-propeller. The propeller 45^b is shown secured to a shaft 45^a aligning with the drive shaft 45 and connected thereto by a coupling 45^c which may be disconnected when the screw-propeller 45^b is not to be used.

The shaft carrying the bevel-gear 28^d may be turned by any suitable mechanism (not shown), such mechanism being preferably so constructed that the shaft 28 may be given a definite angular movement of 90°, 180°, 270°, or 360°. For relatively small vessels, this mechanism for turning or adjusting the center-shaft 28 may be operated by hand, say by providing a suitable crank-handle or the like on the shaft of the bevel-gear 28^d, for larger vessels, this shifting or adjusting mechanism would be operated by power derived from the engine. According to the adjustment of the center-shaft with the cam-track carried thereby, different results would be obtained; thus, if we assume that the vessel will be propelled forward with the shaft 28 in the position which produces the operation illustrated by Fig. 16, then by turning said shaft 28 through an angle of 180°, it will be given a position which will cause the vessel to be reversed, or backed astern, with the main-shaft 20 rotating, in the same direction as before. If the shaft 28 is turned through an angle of 90° or 270° from the position which produces the operation indicated in Fig. 16 (with the main-shaft 20 still rotating in the same direction), into the position Figs. 6^a, 7^a, or 17, assuming that only one feathering-blade propeller is used, or that they rotate in the same direction, if two such propellers are employed, the result of the operation under such changed conditions will be a swinging of the vessel to port or to starboard, that is to say, the propeller will assist the action of the rudder, or steering may be accomplished without the use of the rudder, through the sole action of the propeller or propellers.

When the improved propeller is employed in cases where a raising or a lowering effect is desired at times, as in submarines, or in aerial navigation, one or more of these propellers may be used, applied either in the center of the craft or at each side. Thus, a submarine (Fig. 27) might have two propellers of the character represented in Figs. 7, 7^a, and 19 to 23, placed below the hull, one pair b^1, b^2, at the stern, and another pair, a^1, a^2, farther forward, say amidships, although these forward propellers might be arranged at the bow, if preferred, and various other arrangements might be adopted. Preferably, whenever I employ a pair of horizontal propellers located in the same transverse plane, the two propellers of such pair would be caused to rotate in opposite directions, and their cam-tracks operated in such a manner that each of the two propellers, notwithstanding such difference in the direction of rotation, would have the same effect on the craft. It will be understood that in the case of a submarine, or for aerial navigation, I should employ, preferably, the propeller and cam-track construction of Figs. 7, 7^a, and 19 to 23 inclusive, as with this construction the up-and-down movement of the craft can be controlled readily, in the manner set forth below. In these cases, also, the lower surface of each propeller should be fully exposed to the medium through which the craft is travelling.

The arrangement of a pair of propellers amidships, as in Figs. 2, 2^a, 2^b, and 27 at a^1, a^2 and A^1, A^2 respectively, has the advantage of enabling the ship to be swung or "pivoted" quickly *in situ* or nearly so, about an axis passing vertically through the center of gravity, or close thereto. The same result would be obtained by employing two pairs of propellers, one near the stern, as b^1, b^2 in Figs. 2^a and 27, and the other pair in a corresponding position near the bow.

The detail construction of the propeller and track illustrated particularly by Figs. 19 to 23 inclusive, provides great facilities for vertical steering, that is to say, for causing the craft to rise or descend. Thus, in the case of a submarine, I may, by this construction, steer the boat upwardly to bring it to the surface, or deflect it downwardly to make it "dive", or, in other words, submerge it to a greater or less depth. I desire it to be understood that this detail construction may be applied in other ways than illustrated herein.

For the purpose of exerting a lifting or lowering action on the craft, as referred to above, the blades 27^{a} must not stand vertical at the time of their active or flatwise movement, but in a position inclined to the horizontal, say at 45°, so that each blade impulse will have a component tending to raise or lower the craft. I may employ any suitable mechanism for giving the blades this position in which they have a lifting or lowering effect. Thus, Figs. 7, 7^{a}, and 19 to 23 inclusive show the center-shaft 28 provided with a cam-track of the general character set forth above, but the said track, instead of being rigid with the shaft 28, and while compelled to turn with the center-shaft, is composed of two sections movable relatively to each other, lengthwise of said shaft. For instance, the short horizontal lower portion *m* (Fig. 9) of said track is formed upon a sleeve-segment 29^{c} (Fig. 19) movable lengthwise between the spaced edges of a wider sleeve segment 29^{d} which carries the long horizontal upper portion *n* of the track and is also movable lengthwise of the shaft 28, but held to rotate therewith, as by means of a longitudinal key 29^{e} (Fig. 20). Rings 29^{f} rigidly secured to one of the sleeve-segments, and in loose sliding engagement with the other segment, compel the two segments to remain in contact with each other so that they will complement one another to form a sleeve. Each of the intermediate or connecting portions *o* of the track-forming flanges is in this case made of two members 29^{g} having pin-and-slot connections at their adjacent, overlapping ends, while their other ends are pivoted, as at 29^{h}, to the respective ends of the horizontal flange portions *m* and *n*. Each of the sleeve-segments 29^{c} and 29^{d} is formed with horizontal circumferential grooves (shown at the upper end in Figs. 7, 7^{a}, 19, and 20) constituting rack-sections in engagement with normally stationary pinions 44, 44^{1}, respectively. The upper portion of the sleeve formed by the segments 29^{c}, 29^{d} is also supported by means of bearing balls 28^{b} associated with the pinion 25 and engaging a sleeve 29^{i} secured rigidly to the segment 29^{d} and permitting the segment 29^{c} to slide lengthwise. This construction also provides an additional means for centering the upper portion of the shaft 28 surrounded by the sleeves 29^{c}, 29^{d}. The pinion 28^{c} prevents longitudinal upward movement of the shaft 28.

Any accidental upward or downward movement of the sleeve-segments 29^{c}, 29^{d} is prevented in any suitable manner, and as an example of how this may be accomplished, I have shown (Fig. 19) spring-pressed pawls 53 which normally hold the pinions 44, 44^{1} against rotation in either direction. Any appropriate device may be employed for insuring that the parts, especially the sleeve-segments, will always be stopped in the proper position. For instance, each of the pinions 44, 44^{1} may be limited in its turning movement, as by means of a pin 54 projecting into a segmental slot 44^{11} of the pinion and adapted to arrest the pinion when the end of the slot is reached.

If the pinion 44 engaging the narrow sleeve-segments 29^{c} were mounted in a stationary bearing, the turning of the center-shaft 28 might carry said segment out of engagement with said pinion, leaving said segment free to move lengthwise. In order to prevent this, I prefer to journal the pinions 44, 44^{1} in a carrier 55 mounted to turn with the shaft 28, so that the pinions will always remain in engagement with the respective sleeve-segments. This arrangement is shown in Fig. 19. The carrier 55 is also shown as serving to support the limiting pins 54 mentioned above. Of course, when the pinions 44, 44^{1} follow the rotation of the sleeve-segments 29^{c}, 29^{d}, and of the shaft 28, as just described, it is not necessary to employ grooves extending along the entire circumference of the sleeve-segments, but it would suffice to provide rack-teeth on the segments at the points engaged by the pinions 44, 44^{1}. Any suitable means (not shown) may be employed for turning the pinions 44, 44^{1} to raise or lower the respective sleeve-segments.

With the sleeve-segments 29^{c}, 29^{d} in the position shown in Figs. 7, 7^{a}, and 19 to 23 (corresponding to diagram I of Fig. 24), the blades 27^{a} will be operated in such a way as to stand vertical at the time of exerting their action (in the sector corresponding to the cam-track portion *m*). By turning the pinions 44, 44^{1} so as to shift the sleeve-segment 29^{c} with the track-portion *m* up, and the sleeve-segment 29^{d} with the track-portion *n* down the same distance, all the track-portions

m, n, o may be brought into the same horizontal plane, as indicated in Fig. 23 and in diagram II of Fig. 24. This will cause all the blades, at every point of their travel, to stand inclined, say at 45°, as indicated in said diagram II. A lifting or a lowering effect is thus obtained according to the direction in which the blade-carrying shaft is rotated. By leaving the track-portion m in its original position and sliding only the sleeve-segment 29^d carrying the track-portion n, into the same position as in diagram II, I obtain the position illustrated by diagram III, according to which the blades 27^a, as long as they are in register with the track-portion n, will remain inclined, say at 45°, and will assume the vertical position (resulting in a forward or rearward propelling action) at the short track-portion m. With this adjustment, the blades will have not only a lifting or a lowering effect on the ship, at the track-portion n, but they will also propel the ship ahead or astern by their action at m. With the position indicated in diagram II, there is no propelling action either ahead or astern, for the reason that diametrically-opposite blades will have a counterbalancing or neutralizing influence, so far as propulsion ahead or astern is concerned. The cam-track, while adjustable to different positions as described, is of course, normally stationary during the operation of the propeller, that is, it does not share the rotation of the propeller shaft. The propeller structure described above with especial reference to submarines, may, by building it very light, be applied very advantageously to other crafts, such as airplanes, dirigible balloons, or the like, and their direction determined accordingly, both as to horizontal and to vertical steering. Of course, in the case of vessels adapted to travel only on the surface of the water, the propeller generally will not be adjustable for exerting a lifting or a lowering effect on the ship.

The arrangement of the cranks 30^b relatively to the track should be such that with the blade-carrying shaft rotating in the normal direction, the strain on the shoe-carrying cranks will be a tension or pulling strain, and not a compression or pushing strain. Fig. 9 shows the blade-axis 41 as moving toward the right with the crank 30^b extending rearwardly, that is to say, toward the left from the blade-axis 41 to the shoe 30, so that the crank will always be under a tension strain or pulling strain while the shaft rotates in this direction. In the first position shown at the left, the shoe 30 is at the right-hand end of the track-portion n, and the blade 27^a is in a horizontal position. The crank 30^b is inclined at 45° to the left and upwardly from the axis 41. In the next position shown, the shoe 30 is at the middle of the left-hand inclined track-portion o, the crank 30^b has swung till it is about horizontal, and the blade 27^a is in an inclined position, with its upper edge forward, with reference to the direction of rotation. In the next position shown, the shoe 30 is at the left-hand end of the track-portion m, and the crank 30^b has swung through an angle of 90° from the first position, to a position in which it is inclined at 45° to the left and downwardly from the axis 41; this of course has brought the blade 27^a to the vertical position. In the next position illustrated, the shoe 30 has moved up into the second inclined track-portion o, and both crank and blade occupy positions intermediate beqtween the first and third positions, and similar to the second position, that is to say, the blade is inclined, with its upper edge forward, in the direction of rotation. Finally, at the extreme right, the shoe 30 is at the left-hand end of the track-portion n, and the relative positions of the crank 30^b, blade 27^a, and axis 41 are the same as in the position shown at the extreme left. Fig. 9 shows the horizontal path 42 of the blade-axis 41 as lying just half-way between the horizontal center-lines of the track-portions m and n; this is the arrangement which in my opinion will yield the best results. In this case, the length of the crank 30^b will be equal to the hypotenuse of an isosceles right-angled triangle, the other two sides of which are each equal to one-half of the distance (measured vertically) between the track-portions m and n.

It will be observed that the short horizontal track-portion m is located below the long horizontal track-portion n, and as a result of this arrangement, that edge of the blade 27^a which is forward (with reference to the direction of rotation), will be the upper edge of the blade at all times, as will be evident from Fig. 9, and particularly from the second, third, and fourth positions shown therein. In other words, during the entire time that the blade passes from the horizontal position to the vertical one, or from a position in which the blade plane is perpendicular to the axis of rotation to a position in which such plane is axial, and *vice-versa*, the blade will be inclined with its upper edge ahead in the direction of rotation, and this inclination will cause the blade to exert a downward push on the water, at the time the blade swings from the horizontal position to the vertical one, or *vice-versa*, thereby having a tendency to raise the hull out of the water, which is more conducive to efficient action than if the blades tended to force the hull down at the time of their swinging about their axes.

In the construction illustrated by Figs. 1, 2, and 6, the main-shaft 32 extends through the hull of the vessel and into a tunnel 31 provided below the location of the propeller, and within said tunnel is arranged a neck-and-step bearing 31^a for said shaft. The main-shaft 32 is rotated by a crank-shaft 33 connected with the upper end of said main-shaft, and driven from the power shaft 45 of the engine by means of connecting rods 33^a, a counter-shaft 46 (Fig. 6^a), and bevel-gears 46^a; or any other suitable mechanism may be employed for driving the main-shaft 32. The normally stationary center-shaft 34 (corresponding to the center-shaft 28) has its lower end supported by an anti-friction thrust-bearing 34^a at the bottom of the tunnel 31, the upper end of said center-shaft being received in an anti-friction neck-bearing 34^b at the upper end of the hollow main-shaft 32 (corresponding to the main-shaft 20). Bevel-gear mechanism 34^c, 34^d is provided on the center-shaft within the tunnel 31, for the purpose of adjusting said shaft and the cam-track 29 carried thereby, by turning the center-shaft on its axis, with the same object and result as explained above in connection with the bevel-gears 28^c, 28^d. The lower end of the hollow main-shaft 32 is left open, but packing 31^b is provided to prevent ingress of water into the tunnel along the main-shaft. The construction shown in detail in Fig. 6^a is substantially the same as the one just described, but includes a horizontal partition-plate 31^c arranged in the hollow main-shaft 32 below the hubs of the feathering blades, so as to form a chamber which may be filled with oil (above the plate 31^c) to cause the motion-transmitting parts of the main-shaft and of the blades to run in oil. Of course, this oil-chamber might be used in connection with Fig. 6 also. It will be seen that in fairly large vessels, the hollow main-shaft will be of sufficient size to allow a man to reach easily into the lower shaft portion and loosen the bolts which fasten the partition-plate 31^c to the main-shaft, and also the bolts, such as 29^a, which fasten the upper portion or half of the cam-track 29 to the center-shaft; repairs can thus be made easily to the cam-track and to the actuating mechanism of the blades. The slide-blocks 30 can also be changed if desired, and all other parts pertaining to the blades repaired. The same ease as regards repairs is afforded by the other forms of my invention. When it is desired to remove the center-shaft for repairs, the lower portion or section of the cam-track (that is, the section having the lower flange), is disconnected from the center-shaft by removing the bolts, such as 29^a, securing said lower section to the center-shaft, which can then be removed upwardly, with the upper half or section of the cam-track (having the upper guide-flange) still attached to the shaft, thus exposing the shoes 30 and other parts, and also allowing the lower section of the cam-track to be removed downward readily, into and through the tunnel 31. Similar advantages are obtained, in the case of constructions such as shown in Figs. 7 and 7^a, by making the cranks 30^b readily detachable from the shanks of the blades 27^a, for instance by means of the two-part crank construction indicated in Fig. 9. Upon detaching the small part or cap of the crank, the latter is disconnected from the blades, so that the center-shaft can be removed upwardly, with the entire cam-track and also with the shoes 30 and cranks 30^b, or at least the long or main portions of these cranks. The slide-blocks 30 are preferable to rollers on account of their greater durability.

As has been stated above, when propellers rotating about vertical axes are employed in pairs, with the two axes of the same pair at opposite sides of the longitudinal central plane of the vessel, they should rotate in opposite directions, as indicated in Fig. 16. In this case, whenever the two center-shafts of the same pair are adjusted for the purpose described, they should both be turned in the same direction and through the same angle. It will be obvious that a propeller rotating about a vertical axis arranged in the longitudinal central vertical plane of the vessel, may be substituted for a pair of propellers rotating about vertical axes located on opposite sides of such plane.

Fig. 16 shows that the angle during which the blades are exerting their pushing action on the water or other medium, is about 60°, that is to say, about 30° forward and 30° to the rear of a transverse plane passing through the axis of the propeller, when the ship is being propelled either ahead or astern. When the propeller is operated in such a manner as to swing the ship to port or to starboard, the blades will be in their active position within an angle of 60°, of which approximately 30° will be to the left, and another 30° to the right of a plane extending longitudinally of the ship and containing the axis of the propeller, that is to say, in this case also the angle during which the blades will be active, will be approximately 60°. When the blades are in their active position, with their broad faces perpendicular to their circular line of motion, they act as levers and thus exert a powerful action to propel or to steer the ship. During the remainder of their travel, the blades are inactive and proceed edgewise so as to reduce the resistance to their passage through the water or other medium. It will be understood that the individual blades of the same propeller will reach their inactive position successively, so as to produce a practically continuous action on the water. Since my propeller operates on the principle of a lever, and not by screw action as the usual propellers, I am enabled to utilize the engine power much more efficiently and completely than this is possible with the constructions employed hitherto. It will be noted that (for the sake of simpler illustration) Figs. 1^a, 6^a, 7^a, 17, 18, 19, and 29 do not show the blades 27^a as they will stand during the normal propelling action, but rather as they will stand if the propeller is used for steering. The normal propelling position of the blades, in the case of propellers rotating about vertical axes, is indicated in Figs. 1, 2, 3, 4, 5, 16, 26, 27, 28, and 30.

Figs. 17 and 18 illustrate a vessel of the type of the Argentine battleship "Rivadavia", fitted with a screw-propeller and with a feathering-blade propeller of my improved construction. The latter propeller is arranged substantially like the one described with reference to Fig. 7^a, and its cam-track and center-shaft 28 are of the same character as in Fig. 6^a, but the two propellers shown in Figs. 17 and 18 are arranged at different distances forward of the rudder and also at different levels. The screw-propeller 45^b is mounted on the shaft 45^a connected by the detachable coupling 45^b with the drive shaft 45, the latter, in the construction illustrated by Fig. 17, being shown as operating the shaft 25^b by means of a link-belt 46^b passing over suitable sprockets, while in Fig. 18 I have shown the two shafts 25^b and 45 connected by means of opposed cranks and connecting rods 46^c. This latter connection may be preferable on account of its noiselessness to the connection by gearing or by link-belts shown in other views. Figs. 7, 17, 25, 29, and 30, also show a pocket or well 47 provided in the hull above the feathering-blade propeller and normally closed at the upper end by a removable cover 48, preferably made of two parts, as indicated by the difference in cross-hatching in Fig. 17, said cover having suitable bearings and packings for the shaft 20. At its lower end, the well 47 has a horizontal slideway 47^1 for a sliding gate 49 operated in any suitable manner, as by a pinion 50 in mesh with a rack 49^1. The gate 49 is normally open as shown. When repairs are to be made to the propeller, the latter is raised into the well 47 (after removing the shaft 25^b and its pinion 25^a), than the gate is closed and the cover 48 removed to give access to the propeller from the inside of the hull. The closure 26 is shown as provided with a central downward projection 26^1 supported in a step-bearing 51^1 carried by a bracket or spider 51. The raising of the feathering-blade propeller into the well 47 is also of advantage in cases where, on account of shallow water, it is desired to throw this propeller out of action temporarily, relying at that time on other devices (such as the screw propeller 45^b, Fig. 17) for the propulsion of the ship.

In Fig. 8, I have shown in detail the arrangement of a propeller disposed amidships, to rotate about a vertical axis, as indicated in Figs. 1^a, 2^a, and 5 for the propellers a^1, a^2. The constructive details of this propeller and of its driving mechanism are substantially the same as shown in Fig. 6^a and described with reference thereto, so that further explanation will not be required at this place. Fig. 8 shows how the propeller is adapted to be brought or retracted into a pocket or recess provided in the ship, whereupon the pocket can be sealed water-tight, and then the propeller can be repaired readily, or the same arrangement would be useful for the fitting on of a spare propeller or of a new propeller in the case of loss of the propeller. Packing rings 35, 35^a surround the main-shaft 34 and are held by plates 36 on horizontal slide-plates 37, which are located respectively on the top and bottom plates of the recess or casing 38. Screw-rods 39 connect these slide-plates 37 (directly or indirectly) with stationary brackets 39^a and 39^b attached to the top and bottom plates of the casing 38 respectively. Screw-nuts 39^c, held by said brackets against longitudinal shifting, are adapted to be rotated by suitable gear-wheel transmissions, so as to permit the shifting of the slide-plates with the main-shaft inwardly into the casing 38, thereby bringing the propeller into a position where its blades no longer project beyond the hull. The top and bottom walls of the casing 38 are provided with openings 38^a and 38^b respectively to allow the shaft to be moved inwardly, after the slide-plates and the driving connections of the main-shaft have been disconnected. The shaft and propeller having been shifted inward, a gate 40 movable vertically at the outer portion of the casing 38 is lowered so as to exclude water from the casing, or rather to shut said casing off from the water in which the ship is floating; then the water within the casing 38 is removed, if desired, as by pumping, and repairs may be made to the working mechanism, new blades put on the propeller, the propeller itself exchanged, or other repairs made without requiring the vessel to go into dry-dock. After the desired repairs or replacements have been made, the gate 40 is re-opened, and the main-shaft 34 with the propeller returned to their normal operative position.

Instead of having the lower ends of the shafts 20 or 32 and 28 or 34 located and supported in a tunnel T, as shown in Figs. 1, 1^b, 6, and 28, I may employ a spider construction, one example of which (51) has been described in connection with Fig. 17, while similar constructions are indicated at 51^{11} in Figs. 7, 26 (at the left), 29, and 30. Even the spider may be dispensed with if the shafts are otherwise firmly supported, and instances of constructions in which no special support is provided for the lower end of the hollow drive shaft, are shown in Figs. 4 and 7^a. In cases where the vertical shafts have their lower ends unsupported, or resting on a spider such as 51 or 51^{11}, both mechanisms, the one for driving the hollow shaft, and the other for turning the center-shaft, are connected with the upper portions of said shafts.

In Figs. 2^b, 31, and 32, I have shown two propellers A^1, A^2 arranged to rotate about aligning transverse horizontal axes, said propellers being located amidships, exteriorly of the hull, and corresponding in position to the well-known paddle-wheels. These propellers are feathering-blade propellers of the construction set forth above, and the drive shown in Fig. 31 is substantially of the same character as in Figs. 6, 6^a, and 28. A brace 52 may be provided for securing the free end of the tunnel T^1. Instead of this tunnel, I may provide a spider 51^* (Fig. 33) for supporting the outer end of the hollow main-shaft, the inner ends of said shaft and of the center-shaft being in this case connected with any suitable driving mechanism, say one of the characters indicated in Figs. 29 and 30. Fig. 33 also shows a gate 49^{11} of the same type as the gate 49 of Fig. 17, but of course the gate of Fig. 33 is vertical instead of horizontal. Wells such as 47 and gates such as 49, 49^{11} might be employed in conjunction with other forms of my invention as well. It will be understood that the several features of my invention may be combined in many ways other than those illustrated in the drawings.

While the forms of my invention described and shown herein are such as I consider satisfactory and particularly adapted for conditions of practical use, it will be obvious that changes may be made therein without departing from the spirit of my invention.

I desire to give at this point, a summary of the advantages offered by my new propeller over those employed at present in the merchant marines and the navies of different countries:

1) Material increase of speed, and this without increase of engine power.

2) In case a large ship loses a propeller, or suffers injury through breaking of the propeller or of the drive shaft, there is no need of bringing the ship to dry-dock or otherwise putting it out of commission.

3) The danger of collision with other ships or with derelicts or other obstacles is avoided almost entirely on account of the possibility of immediately swinging the bow or the stern of the ship off the course, and also on account of the ease with which the ship's headway can be checked in case of need.

4) Rolling of the ship is almost entirely suppressed, because, when propellers are arranged on each side of the ship, they counteract any tendency of the ship to swing about its center of gravity.

5) When the propellers are disposed amidships, the length of the propeller shaft will be only about one-third of the length required under present conditions, and for this reason the construction of the new propeller and its adaptation to, or installation in, ships will cost less than in the case of the usual propellers.

6) The manœuvring ability of the ship is greatly increased; in particular, (*a*) with the ship proceeding at full speed, it should be possible to stop, or change the course to one at right angles to the former course, in one-fourth of the mini-

mum time required for this purpose with ordinary propellers; (*b*) by changing the operation of the propellers so that they will exert a lateral action (to port or starboard), the ship can be swung very rapidly and even turned or "pivoted" *in situ*, while stopping its progress; (*c*) the possibility of giving the ship as great a speed astern as ahead, by a proper adjustment of the cam-track. These last two are great advantages in the case of men-of-war, where retreat at full speed, without turning around, and the possibility of swinging on a pivot, as it were, are of evident utility in certain cases.

7) The new propeller is readily applied, not only at the bow, at the stern, and amidships, but in various intermediate positions, which is of especial advantage in securing an efficient action, for the following reasons: It is well-known that with ships of great horse-power, it is impossible, for practical considerations, to transmit the full engine power to a single propeller, and it has been found that it is not advisable to transmit more than 10,000 or 15,000 horse-power to one propeller, thus a ship with engines of say from forty thousand to sixty thousand horse-power will according to present practice require three or four propellers. Now, with the present screw-propellers, when two or more are employed, they are all arranged near the stern, and therefore at a relatively small distance from each other. This is highly detrimental to efficient operation, for the reason that some of the propellers will be arranged in front of the others, and the front propellers, which are fairly efficient, since they operate on relatively quiet water, will whirl this water in the direction of rotation, so that the propellers located in the rear will act on water whirling in the same direction as the rear propellers, so that the propelling efficiency of these rear propellers is diminished to a very large extent. This is one of the great drawbacks encountered whenever, on account of high horse-power, several screw-propellers are employed at the stern of a ship. This difficulty is overcome completely and readily by the use of my new propellers, since they can be arranged at such distances from each other that the whirling motion created by the rear propellers will have stopped or decreased materially, by the time the same water is acted on by the next propellers in the rear, so that each propeller will operate with practically the same degree of efficiency. For instance, a ship may have ten propellers of my improved type arranged in five pairs, one pair near the stern, and the others amidships, at different distances from the stern, and at different levels. By arranging the propellers at different levels, they may be caused to operate on different portions of the water, even when their axes are relatively close together, thus bringing the majority of the propellers, if not all, close to the engine. The number of propellers might be a dozen or more, yet the cost of constructing and applying these propellers to the ship, will be less than the corresponding cost in connection with say four screw-propellers applied at the stern in accordance with the usual practice; furthermore, this dozen feathering-blade propellers will take much less space than said four ordinary screw-propellers. Besides, the loss of power will be reduced considerably by substituting my new propellers, the propellers will be smaller and therefore more easily repaired than the correspondingly larger screw-propellers, the transmission of power will be more efficient and economical, and from all points of view, this new propeller construction and arrangement will appear to be of eminent practical utility in connection with ships and other crafts.

A feathering blade structure of this character may be used not only as a propeller, but as a pump for sucking and forcing water or other liquid, as a ventilator or blower for air or gases, and also, when exposed to the action of a liquid or gaseous current, as a motor for obtaining power from such current.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A structure adapted for use in the manner set forth, in which the normally stationary cam or track for guiding and operating the members effecting the swinging of the feathering blades on thei axes comprises two portions connected b intermediate portions to form a continuous contact surface or surfaces sai two portions being located in planes a equal distances from and on opposite side of the plane containing the blade axe and perpendicular to the axis of rotati of a tubular rotary member surroundi the cam or track and on which the blad are mounted.

2. A structure adapted for use in t manner set forth, in which the norma stationary cam or track for guiding a operating the members effecting

winging of the feathering blades on their
xes comprises two portions located in
lanes perpendicular to the axis of rota-
ion of a rotary member carrying the
lades, and means provided whereby said
ortions can be adjusted longitudinally
elatively one to the other or axially with
espect to the axis of rotation of the
otary member.

3. A structure adapted for use in the
manner set forth in Claims 1 or 2, where-
n the intermediate portions each consist
f two members overlapping at two of
heir ends and connected at said ends to
ermit of sliding movement relatively
ne to the other and pivotally connected
t their opposite ends to the respective
ends of the two portions of the cam or
rack.

4. A structure as claimed in Claims 1,
2 or 3, wherein means is provided for
varying the angle which the blades when in their active positions form with the plane of rotation.

5. In a structure of the character set forth in Claim 2, the provision of teeth on the longitudinally adjustable cam track portions, to mesh with adjusting pinions mounted to share the circumferential adjustment of the entire cam-track.

6. A structure as claimed in any of the preceding claims wherein is provided a well into which the propeller may be withdrawn upwardly into the hull of the craft, and a gate to close said well when desired.

7. The improved forms of propeller for ships and other purposes substantially as described with reference to the accompanying drawings.

Dated this 20th day of March, 1919.

MARKS & CLERK.

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